

# SPEC 4310

## Artificial Intelligence 1

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# Course Topics

Introduction to AI

Prolog

Expert systems

Solving Problems by Searching

- Uninformed search algorithms
- Heuristic guided search
- Local search algorithms and genetic algorithms

Knowledge Representations and Inference

- First Order Predicate Logic
- Logical Inference, ...

Constraint Satisfaction Problems

Adversarial Search and Game Play

# Assessment

- 70% Written Exam at end of Semester 1
- 30% Continuous Assessment
  - Two Prolog lab tests – week 6 and week 11

# Labs

SWI-Prolog

<http://www.swi-prolog.org/>

# Books

<http://library.dit.ie/>

Russel, S. & Norvig, P. “Artificial Intelligence - A modern approach”, 3<sup>rd</sup> ed, ©2010, Pearson.

Negnevitsky, M. “Artificial Intelligence – A Guide to Intelligent Systems”, 3<sup>rd</sup> ed, ©2011, Addison Wesley

Luger, G “Artificial Intelligence: Structures and Strategies for Complex Problem Solving (6th Edition)”, Addison-Wesley

# Course Materials

All materials available through webcourses

SPEC4310: CMPU 4010: Artificial Intelligence 1

Password: **prolog**

# **INTRODUCTION TO ARTIFICIAL INTELLIGENCE**

Russel, S. & Norvig, P. "Artificial Intelligence - A modern approach", 3<sup>rd</sup> ed, ©2010, Pearson.

# AI: What is it?

We call ourselves *Homo sapiens* (man the wise) because our mental capacities are so important to us

For thousands of years, we have tried to understand *how we think*

The field of **artificial intelligence** (AI) goes further still: it attempts to not just understand but also to build **intelligent** entities.



# Are these intelligent?

- Waving your hand
- Understand what am I saying
- Write a novel
- Remember who won 1926 All Ireland
- Diagnose a clinical disease
- Provide directions from Kevin St to Grafton St
- Find roots of quadratic equation
- Predicting the weather

# AI: What is it?

## What is intelligence? **Open questions**

- Is intelligence a single faculty, or is it just a name for a collection of distinct and unrelated abilities?
- To what extent is intelligence learned as opposed to having an a priori existence?
- Exactly what does happen when learning occurs?
- What is creativity?
- Can intelligence be inferred from observable behaviour, or does it require evidence of a particular internal mechanism?
- ...

# AI: What is it?

4 views of AI

Thinking humanly	Thinking rationally
Acting humanly	Acting rationally

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Thought processes and reasoning versus behaviour.

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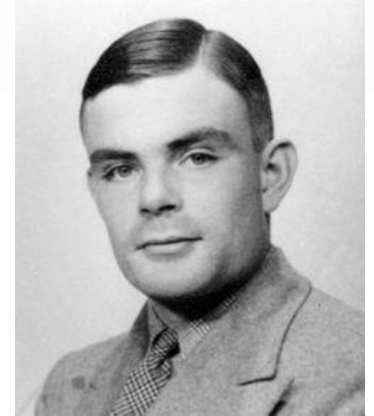
Human performance **versus** rationality.

*Rationality is an idealised concept of intelligence. A system is rational if it does the “right thing”, given what it knows.*

# Acting Humanly: Turing Test Approach

Alan Turing (1912-1954)

English mathematician, logician, computer scientist and cryptanalyst



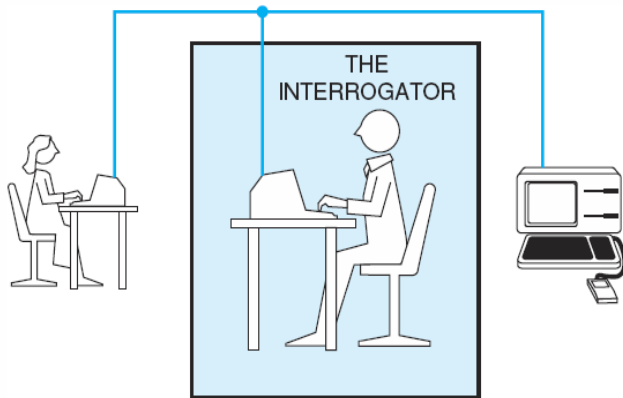
During the WW2 worked at the British Government Code and Cypher School, devising number of techniques for breaking German cyphers

After the war he worked in the National Physical Laboratory where he worked on ACE (first designs of program-stored computer)

Prosecuted in 1952, and died by cyanide poisoning 1954

# Acting Humanly: Turing Test Approach

The **Turing Test**, proposed by Alan Turing (1950), was designed to provide a satisfactory operational definition of intelligence.



- Measures the **performance** of an allegedly intelligent machine against that of a human.
- Machine, human and the **interrogator** in separate rooms (communication via computer terminal)
- The interrogator is asked to **distinguish the computer from the human** being solely on the basis of their answers to questions asked over the device.

If the interrogator cannot distinguish the machine from the human, then, Turing argues, the machine may be assumed to be intelligent.

# Acting Humanly: Turing Test Approach

The **total Turing Test** includes a video signal and the interrogator can pass physical objects “through a hatch”. To pass the total Turing test, the computer will need the following capabilities:

1. **Natural language processing**: to communicate in English
2. **Knowledge representation**: to store what it knows and hears
3. **Automated reasoning**: to use the stored information to answers questions and draw new conclusions
4. **Machine learning**: to adapt to new circumstances and to detect and extrapolate patterns
5. **Computer vision**: to perceive object
6. **Robotics**: to manipulate objects and move about

These six disciplines compose most of AI.



# Acting Humanly: Turing Test Approach

## Advantages

- It attempts to give an objective notion of intelligence that avoids debates over its “true” nature, i.e., the behaviour of a known intelligent being in response to a particular set of questions.
- Avoids the process/product debate: whether or not the computer uses the appropriate internal processes or whether or not the machine is actually conscious of its actions.
- Eliminates any bias in favour of living organisms by forcing the interrogator to focus solely on the content of the answers to questions

# Acting Humanly: Turing Test Approach

## Criticisms

- Bias towards purely symbolic-solving tasks. It does not test abilities requiring perceptual skill or manual dexterity.
- Needlessly constrains machine intelligence to fit a human model. Perhaps machine intelligence is fundamentally different from human intelligence?
- Lady Lovelace's Objection: computers can only do as they are told and consequently cannot perform original (hence, intelligent) actions.
- Argument for Informality of Behaviours: impossible to create a set of rules that will tell an individual exactly what to do under every possible set of circumstances.

# Turing Test: Eugene Goostman

Eugene Goostman – chatbot pretending to be a 13yo boy living in Ukraine

Fooled 33% of the judges in the Turing Test 2014 competition

Criticism: using personality quirks and humour as distraction

# Thinking Humanly: The Cognitive Model Approach

We can analyse the actual workings of human minds in two ways:

- Introspection (examining our own ideas, thoughts, feelings)
- Psychological experiments

Trying to build a theory/model which then to implement in a computer program

If the program's input/output and timing behaviours match corresponding human behaviours, that is evidence that some of the program's mechanisms *could* also be operating in humans.

The field of *cognitive science* brings together

- computer models from AI and
- experimental techniques from psychology, biology, chemistry

# Thinking Rationally: The “laws of thought” approach

Aristotle was the first to attempt to codify “right thinking”. His **sylogisms** provided patterns for argument structures that always yielded the correct conclusions given correct premises: “**Socrates is a man; all men are mortal; therefore, Socrates is mortal**”.

These **laws of thought** initiated the field called **logic**.

In the 19th century logicians had developed a **precise notation** for statements about all kinds of things in the world and about the relations among them.

By 1965 programs existed that could, **in principle**, **solve any solvable problem described in logical notation**.

The so called **logician** tradition within AI hopes to build on such programs to create intelligent systems.

# Thinking Rationally: The “laws of thought” approach

## Problems with the logicist tradition:

- It is not easy to take informal knowledge and state it in the formal terms required by logical notation, particularly when the knowledge is less than 100% certain.
- There is a big difference between being able to solve a problem “in principle” and doing so in practice (**combinatorial explosion**).
  - Even problems with just a few dozen facts can exhaust the computational resources of any computer unless it has some guidance as to which reasoning steps to try first.

# Acting rationally: The rational agent approach

An **agent** is just something that acts (agent comes from the Latin *agere*, to do)

A **rational agent** is one that acts so as to achieve the best outcome or, when there is uncertainty the best expected outcome.

**Limited rationality**: acting appropriately when there is not enough time to do all the computations one might like.

Note: AI as rational-agent design is more general than the “laws of thought” approach, because correct inference is just one of several possible mechanisms for achieving rationality (reflex actions do not require inference, yet they can still result in achieving the best outcome!).

# AI: What is it?

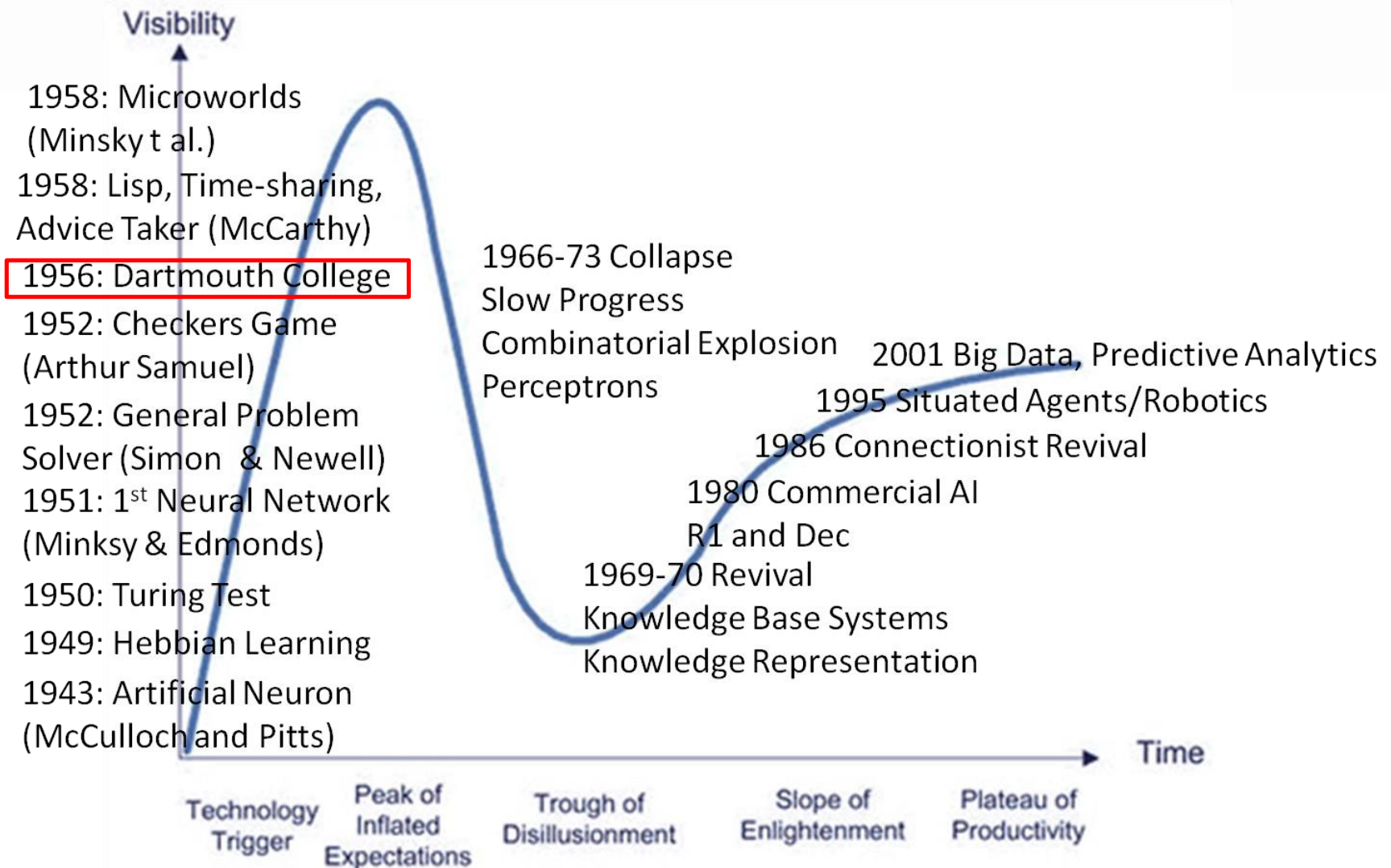
The branch of **computer science** that is concerned with the automation of rational behaviour.

It includes:

- **Data structures** used in knowledge representation
- **Algorithms** needed to apply that knowledge
- **Languages and programming techniques** used in their implementation



# AI: Hype Cycle



# State of the Art



# State of the Art

**Autonomous planning and scheduling:** (2000) NASA's Remote Agent program became the first on-board autonomous planning program to control the scheduling or operations for a spacecraft.

**Game playing:** (1997) IBM's Deep Blue became the first computer program to defeat the world champion in a chess match.

**Autonomous control:** The ALVINN computer vision system was trained to steer a car to keep following a lane and was used to navigate across the US - for 2850 miles it was in control of steering the vehicle 98% of the time.

**Diagnosis:** Medical diagnosis programs based on probabilistic analysis have been able to perform at the level of an expert physician in several areas of medicine.

# State of the Art

**Logistics planning:** During the Persian Gulf crisis of 1991, US forces deployed an AI system to do automated logistics planning and scheduling for transportation. This involved 50,000 vehicles, cargo and people at a time, and had to account for starting points, destinations, routes and conflict resolution among all parameters.

**Robotics:** many surgeons now use robot assistants in micro-surgery.

**Language understanding and problem solving:**

Proverb (Littman et al., 1999) is a computer program that can solve crossword puzzles better than most humans, using information from a variety of sources.

Watson (IBM 2011) – won on Jeopardy! against previous champions  
Siri (Apple)

... many more...

# State of the Art

... Many more!

It's very exciting and rapidly changing time for AI!

# Questions?

